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The Dynamic Test of Cantilever Arrays Using Laser Doppler Principle on Platform of NMM

ABSTRACT

In order to evaluate the MEMS devices' dynamic mechanical properties, laser Doppler method is introduced. Combined with NMM, Polytec vibrometer is used to construct a dynamic measuring system with a large range and high precision. The resonant frequency and vibrating amplitude of a cantilever is measured. The experimental results are discussed.

1. INTRODUCTION

In the fabrication of certain MEMS devices, such as cantilever arrays and micro-mirror arrays, there is an urgent demand to evaluate MEMS devices' dynamic mechanical properties^[1]. Because laser Doppler method can only perform single-point measurement in a small area, not the whole surface information, its application in the dynamic test of devices is limited seriously. In order to extend measurement area of laser Doppler method, the NMM (Nano Measuring Machine) with a large range and high precision is introduced in the field of dynamic test and evaluation of the cantilever.

2. EXPERIMENT SETUP AND METHOD

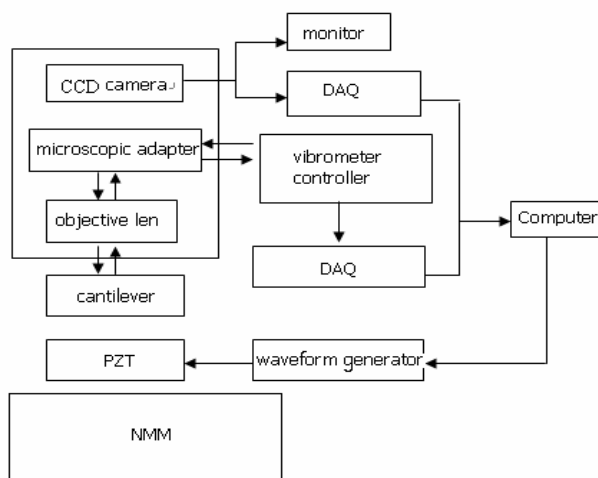


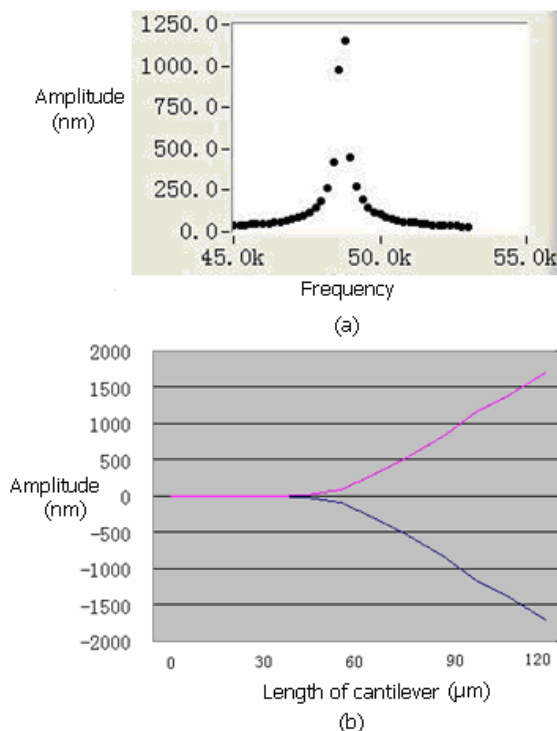
Fig. 1 Structure of the measuring system

Compared with the traditional positioning methods, such as PZT and stepping motor, the NMM improves the precision and scanning range. Meanwhile, the NMM minimizes the influence of scanner's characteristics^[2]. Adaptive error compensation in the full range of motion is achieved by close-loop operation with five degrees of freedom. The high accuracy is obtained by a zero Abbe offset arrangement with three plane

mirror miniature interferometers, two angular sensors and environmental sensors. The structure of the measuring system is shown in Fig.1. The stimulating signal from an arbitrary waveform

generator is exerted on a PZT film, and then the mechanical vibration is transmitted to the cantilever. The laser beam is focused by a microscopy to reduce the diameter of light spot, and reflected by the cantilever with vibrating information. Through the precise movement of NMM sample stage with 0.1nm resolution, the multi-point scanning measurement is performed. This optical signal is converted into the electronic signal and gathered by a data acquisition card. The data process is achieved by the control software.

3. RESULTS AND DICUSSIONS



**Fig. 2 (a) Resonant frequency of the cantilever
(b) Vibrating amplitude of the cantilever**

Integrating with NMM, the laser Doppler measuring system can perform the multi-point test on the cantilever. The scanning range of laser Doppler system is expanded to $25\text{mm} \times 25\text{mm} \times 5\text{mm}$. The maximum value of velocity and displacement measurement is 10m/s and $50\mu\text{m}$ respectively. The diameter of light spot depends on the magnification of the microscope objective. The minimum value is $1.25\mu\text{m}$ with $40\times$ magnification. The highest frequency measured is 20MHz with 0.01nm resolution.

In our experiment, a cantilever with the dimension of $125\mu\text{m} \times 55\mu\text{m} \times 4\mu\text{m}$ is measured. The resonant frequency is about

48.8kHz, and at the end of the cantilever, the vibrating amplitude has the maximum value 1699.6nm, as shown in Fig 2(a) and (b).

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